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Water Purification by Ozone

Electrical Engineering

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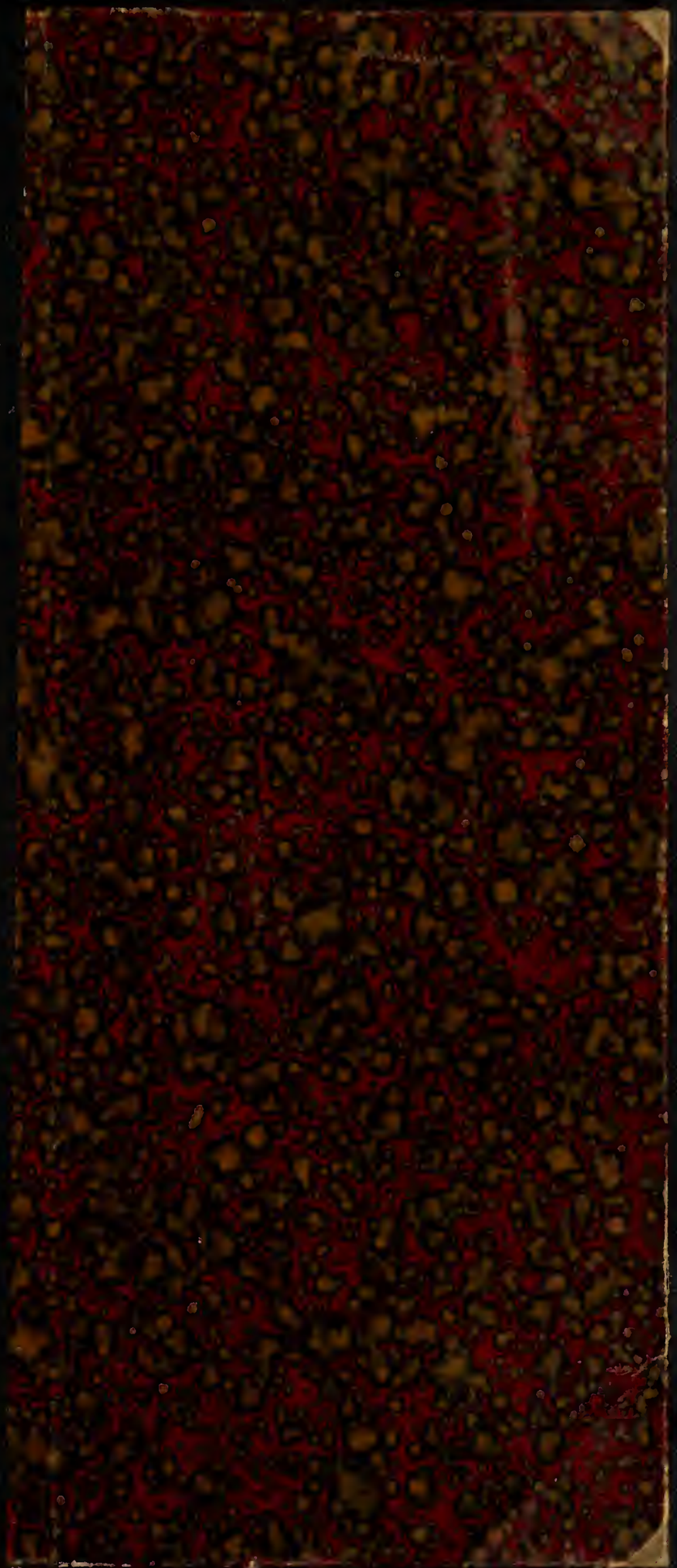

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# WATER PURIFICATION BY OZONE

BY

CHARLES THOMAS ANDERSON
JOSEPH NATHANIEL STEINGARD

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THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

ELECTRICAL ENGINEERING

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COLLEGE OF ENGINEERING
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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Charles Thomas Anderson and Joseph Nathaniel Steingard

ENTITLED Water Purification by Ozone.

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Electrical Engineering

J M Bryant
Instructor in Charge

APPROVED: Ernst J Berg

HEAD OF DEPARTMENT OF Electrical Engineering

197533

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## Introduction.

In 1785 it was discovered by Van Marum that a disruptive discharge of electricity through air is accompanied by a peculiar odor. The cause of this odor was not known until 1840 when Sconbein, a swiss chemist, discovered it to be a gas then unknown to chemistry. Sconbein found that the new gas which he called ozone, is an allotropic form of oxygen produced by the passage of an electric current through ordinary oxygen, and that it is very unstable, decomposing easily into ordinary oxygen. It was found that because of this instability ozone is a very active oxidizing agent. As such it has been found applicable as a bleacher and as a purifier. Of particular importance is its use in sterilizing drinking water.

Drinking water is known to be the medium of distribution of many diseases such as cholera and typhoid fever. The bacteria causing these diseases contaminate the water of rivers and lakes atcertain times. They are so small that they escape the filters. Apparently clean water may therefore contain dangerous bacteria. Among the methods in use at present for the destruction of these, is the use of ozone. This gas is to a considerable degree soluble in water. If dissolved in impure water it attacks any organic matter present. In sterilizing water which has previously been filtered to remove the coarse impurities, ozone has proved successful. Filters must be used in connection with the process, however, because otherwise the ozone, unless supplied in excessive quanities, merely attacks the coarser forms of organic material leaving the bacilli unharmed. The cost of the production of ozone prohibits such excessive use. Filters and other devices must be used to render the the water comparitively clean

before ozone is used to put on the finishing touches.

The most convincing application of ozone for water purification is a plant of this kind lately installed at St. Petersburg, Russia. This plant purifies over 13,000,000 gallons of water daily. The impure water of the Neva River is first filtered to remove coarse impurities. It is clarified by use of aluminum sulphate and allowed to deposit sediment in tanks. It is then forced through injectors which draw ozone from the ozonizers and mix it with the water before it is forced into water towers where the ozone collects in small bubbles and rises through the water to the tops of the towers. Part of the sterilization takes place in the injectors, and part of it takes place as the ozone rises in a finely divided state through the columns of water.

Some of the details of this plant are of interest. The ozonizers are of the Siemens and Halske type depending on the silent discharge of electricity or corona between the plates and the separating insulators. There are 128 of these ozonizers. They are operated on a 500 cycle per second voltage of 7000 volts. The air is drawn through them by the vacuum caused by the Otto injectors, which operate on a 14 foot head of water. The concentration of the ozone produced is 2.5 grams to the cubic meter of air and ozone. The power equipment of the plant consists in two steam engines of 150 horse power, directly connected to three-phase generators. The power is used not only to produce the ozone but to operate the pumps and various devices about the filters. As for the cost of operation it may be estimated at 0.4 to 0.45 of a cent for each cubic meter of water, for the whole process. The ozonizing alone costs approximately half of this.

The results of the process seem to be all that could be desired. Dr. Erlwein says:-

"With respect to the physical and bacteriological purification effects, this combined rapid filterationand ozone system fulfills all expectations. The dirty river water of the Neva is changed into a clear and hygienically perfect drinking water. The number of bacilli spores in the ozonized water is very low, varying between 0 and 3 per cubic centimeter. Coli bacteria or pathogenous spore of cholera and typhoid are not found in sterilized water."

Careful examinations were made by expert bacteriologists to prove the success of the attempt before the commercial plant was opened. This committee of experts tested the water in an experimental plant, treating 100 cubic meters per hour.

With the assurance that water can be purified by ozone, it was thought possible to construct small ozone generators for individual water faucets.

The original purpose of this thesis was to design a successful plant of this type the cost of which would not be prohibitive.

There is some question as to the practicability of the proposition, considering the data taken. The thesis may therefore be rather a discussion of the possibility of a successful design and construct- of a private ozone water purifier, than an actual design. Considering the project perfectly possible and practicable, it cannot be expected that persons previously ignorant of the conditions of the problem should delelop, in the short time allowed, anything like a scientific or commercially successful apparatus.

(1) "The New Ozone Purification Plant etc." By Dr. G. Erlwein Metallurgical and Chemical Engineering Vol IX No. 4. Apr. 1911.

In the following pages will be given the experimental data taken, the curves drawn from this data, a discussion of results and conclusions.

## Method.

This problem requires a quick and simple means of mixing ozonized air with a stream of water flowing from a faucet. For this purpose the aspirator principle naturally lends itself. This form of device was chosen on the assumption that the ozonized air, drawn in by the aspirator and mixed with the water, has time to sterilize the water before the gas escapes from the receiving vessel. It is possible however that further mixing is necessary for complete sterilization. But it is evident that under the conditions of this problem it is very desirable to avoid any such complication. It was therefore decided to use an aspirator as a mixing device.

The form of ozone generator chosen is that which depends for its action on the passageof electricity through air in the form of a silent discharge or corona. In order to produce corona and to avoid sparks a sheet of insulating material was inserted between the electrodes between which the discharge was caused to take place. The electrodes were plates of metal separated by a glass or mica sheet and an open space through which air could be caused to pass. These places were connected to the terminals of a transformer the voltage of which could be adjusted to any value between 0 and 10,000 volts. Through the center of one of the plates a tube was passed into the air space between the plates. This opening to the air space was connected to the aspirtor by means of glass tubing.

With this form of apparatus, the air which is pumped by the aspirators through the ozonizers and mixed with the water is partially ozonized by the corona between the plates. The ozone absorbed by the water depends upon the concentration of ozone in the ozonized air. The concentration depends upon the rate of flow of air through the

ozonizer and the current through the air in the form of corona. This in turn depends upon the voltage impressed and the distance between plates. All of this is on the assumption that the size of plates and the insulating sheet thickness and material remain the same.

The method was therefore to determine by experiment the variation of ozone concentration with the voltage, rate of air flow, and distance between the electrodes. The voltage could be varied by adjustments on a potentiometer form of rhostat giving various values of voltage impressed on the low tensionside of the transformer. The ratio of transformation was 100 to 1 so that a low voltage voltmeter across the low tension terminals indicated the high voltage impressed across the ozonizer. The rate of air flow could be adjusted by means of a valve supplying water to the aspirator. A gas meter was used to ascertain the rate of flow. The distance between electrodes was maintained by use of four small rectangles of insulating material, being placed one under each corner of the upper plate. The distances could be varied by using different thicknesses of these separating blocks. From these variations of ozone concentration it is desired to choose the most favorable conditions.

In order to determine as accurately as possible these variations the method was to hold all factors except one, constant, to vary this and to note the corresponding variation in ozone concentration. After making many preliminary tests, certain ranges of voltage, rate of air flow, and distance between electrodes were adopted as covering the most favorable conditions. Two extremes of distances between electrodes were chosen. For each of these distances sufficient data was obtained for a curve between voltage and ozone concentration, and a curve between rate of flow of air and concentration. In getting the data for the voltage curves the dataof preliminary runs was studied

in choosing the most favorable rate of flow of air. In like manner in choosing the constant voltage for the rate curve, the preliminary data was considered.

The method of measuring the concentration of ozone in the ozonized air involved the most delicate part of the experiments. This measurement was accomplished by passing the gas to be tested through a solution of potassium iodide and by measuring the quanity of iodine freed as an index to the quanity of ozone absorbed by the solution. The quanity of iodine freed was measured by neutralizing it with a solution of normal concentration of sodium thiosulphate. The number of cubic centimeters of the normal solution added to the iodide solution before the color due to the iodine disappeared indicated the quanity of iodine present in free state; and through known chemical equations it also indicated the number of liters of ozone at normal pressure and temperature. Knowing the number of liters of ozonized air pumped through the solution and the number of liters of ozone obtained, the concentration could be calculated.

The chemistry of the problem deserves a more minute consideration.

When ozone comes in contact with potassium iodide solution, a chemical reaction takes place which liberates iodine and oxygen and produces potassium hydrate according to the following equation

$$2KI + O_3 + H_2O = I_2 + 2KOH + O_2$$

The iodine gives the solution a yellow color. This color disappears as sodium thiosolphate solution is added.

The chemical reaction is as follows:-

$$I_2 + 2Na_2 S_2O_3 = Na_2S_4O_6 + 2 NaI$$

When only a small trace of free iodine remains in solution the color cannot be detected. Therefore for the last few drops of thiosulphate

added, the criterion is supplied by adding a few drops of starch solution which turns a deep blue color in the presence of a slight trace of iodine. When the blue color disappears practically all of the iodine has been neutralized.

The chemical measurements are more accurately defined as follows. A one tenth normal solution of sodium thiosulphate ($\frac{n}{10}N_{a2}S_2O_3$) was made by titrating against standard iodine solution. One liter of $\frac{n}{10}N_{a2}S_2O_3$ was added to nine liters of distilled water making the solution $\frac{n}{100}N_{a2}S_2O_3$ or one one hundredth normal solution of sodium thiesulphate, now it is known that one cubic centimeter of $\frac{n}{100}N_{a2}S_2O_3$ neutralize a quanity of ($I_2$) which would result from the action of .00012 liters of ozone ($O_3$) on (KI) solution. Therefore if the number of c.c. of thiosulphate used be multiplied by (.00012), the liters of ozone at 760 m.m. pressure and 20°C. is the result. If one liter of air is registered in the gas meter, this number multiplied by (100) is the percentage concentration of ozone. If more or less than one liter passed, this result must be divided by the number of liters of ozonized air concerned.

Suppose that 10 cc of $\frac{n}{100}N_{a2}S_2O_3$ is used and that 4 liters of gas is measured by gas meter. Then $\frac{10 \times .00012 \times 100}{4} = .03$ % concentration.

To collect the ozone from the ozonized air, the mixture was caused to flow through two wash bottles containing the iodide solution. It was assumed that all of the ozone was collected in these two bottles. The arrangement may be seen on the drawing of apparatus given herein. (Plate 1.)

For the water sterilization test the ozonizer was connected directly by glass tubing to the aspirator. The aspirator was fed by water which was piped through a beer keg into which cultures of cer-

tain bacteria had been introduced. A cock was provided above the aspirator for the purpose of obtaining samples of impure water to correspond with samples taken from the ozonized water.

## Manipulation and Results.

The plates of the ozonizer were four inches square. The insulator used between them was a sheet of mica, .025 centimeter in thickness. This sheet was placed upon the lower metal plate. Upon the four corners of this sheet were placed the fiber blacks to provide the air space. Upon these the upper metal plate was laid. Two thicknesses of the separating fiber blocks were used giving distances between the plates of .059 inches and .033 inches.

Since the plate beneath the mica was protected against the ozone its material was of little importance; it was of brass. But the upper plate being exposed to the action of the ozone, reacted with more or less of the gas introducing an error into the results. For this reason two metals were tried as the upper plate, one of brass and one of aluminum.

Each of the upper plates was used for the two chosen distances as air space; and sufficient data was obtained for a voltage-concentration curve and fora rate of flow-concentration curve. These eight curves represent the results of the ozone concentration test. From these curves were chosen the conditions for the water sterilization test.

The aluminum voltage curve for the distance .059 inches between plates, or curve number 4, was chosen as the most reliable for reference. Using this voltage and distance and plate, impure water was passed through the aspirator at various rates. Samples of the impure and of the ozonized water were taken. These samples were analyzed by the University water analysis department. Of these tests only two appeared to be worthy of note. The first showed a reduction of bacteria from 27000 to 16400 or the destruction of 11600, a percent-

age of 43. The average velocity of air through the ozonizer was 20.8 feet per minute for this test. The second test showed a reduction of from 20000 to 8400 or a destruction of 11600, a percentage of 58. The velocity of air in this case was only 10.9 feet per minute. This latter velocity may be compared with that used in the curve of voltage number 4, which was calculated as 78. feet per minute.

At voltages of 4800 and 5000 Volts across the ozonizer measurements of current and power consumed in corona were made. On page 31 are given the results, for the two air space distances, in tabular form.

At 4800 Volts and for the larger distance between plates which was chosen as most favorable the current was .00375 amperes giving a current density of .00029 amperes per square inch and a power consumption of 18 watts. For the smaller distance the current was .00542 giving a current density of .00042 amperes per square inch of plate and a power consumption of 26 watts.

At 5000 volts and for the larger distance the current was .0049 amperes giving a current density of .00038 amperes per square inch and a power consumption of 23.5 watts. For the smaller distance between plates and 5000 volts the current was .0057 amperes giving a current density of .00044 amperes per square inch and a power consumption of 28.5 watts.

## Discussion and Conclusions.

The curves are numbered in pairs, 1, 2, 3 and 4. The speed curves were taken at such voltages as gave the maximum concentration as shown by the voltage curve of the same numbers. For instance the maximum concentration on voltage curve no. 4 is near 4800 volts. The constant voltage for speed curve no. 4 was chosen as 4850 volts. This discrepancy is due to the fact that roughly plotted curves were used during the experiment. Each speed curve was taken immediately after its corresponding voltage curve. This eliminated variations in such conditions as humidity of the air, temperature, etc.

The brass curves show a heavy loss of ozone possibly due to chemical action. The aluminum curves showed a higher concentration than did the brass. This is probably due to the fact that aluminum oxide forms a homogeneous layer over the metal protecting it from further oxidation. The aluminum for this reason proves much superior to brass for this purpose.

The aluminum curves no. 4 are chosen for particular reference. These two curves are reasonably uniform. But the others may not signify much except to illustrate roughly the variations of concentration with corona, distance, and electrode material.

It will be noticed that the best conditions of operation as shown in curve number 4 are a voltage of 4800 volts and a rate of 4 liters in 53 seconds. The concentration for these conditions is about .06 per cent. Now for the water sterilization test which showed the better results, 1.894 liters of water passed through the aspirator in 90 seconds. And as it is known that the aspirator pumps a volume of air half as great as that of the water passing, it is known that 0.947 liters of air passed through the appartus in 90

seconds. This rate is equivalent to 4 liters in 380 seconds. Now, referring to the speed curve number 4, at 380 seconds, a concentration of roughly 0.18 % is indicated. This evidently is the concentration which effected the 58% sterilization.

We could therefore reduce the rate of flow through the aspirators to 4 liters in 380 seconds. But this would not allow enough water for practical purposes to pass through the aspirator. Instead of changing the water rate the desired result could be accomplished by using an ozonizer having seven air spaces instead of one (the ratio of speeds is 7) in parallel so that the velocity of flow in each would be 1/7 of that in one air space if used alone.

But to be on the safe side let us consider ten spaces, or eleven plates with the same dimensions, same distances for air space, etc. $\frac{10}{7}$ x 380 seconds gives us a time of 542 seconds. The concentration for 4 liters in this time can only be estimated on speed curve no. 4. But it seems to exceed somewhat 0.2%. This concentration it is believed would be sufficient to sterilize completely the average of water supplies if a simple mixture device be used in connection with the aspirator.

It is therefore suggested that such an ozonizer and sterilizing set as illustrated diagramatically on plate 3 could be successfully constructed and used.

The mixing device illustrated on plate 3 is merely a piece of wire gauze at the outlet of the aspirator followed by a staggered pipe of sufficient length to allow most of the ozone to be absorbed by the water. This length of staggered pipe is a matter of experiment.

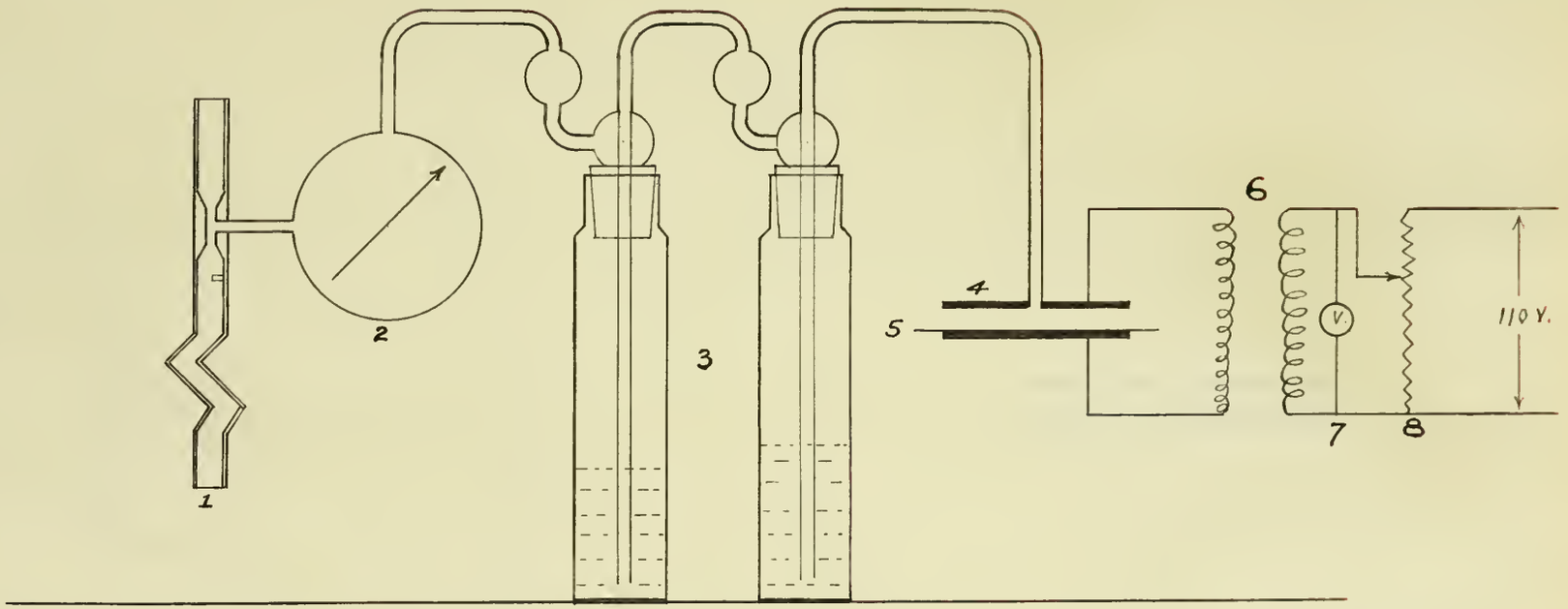
Another auxilliary device of value for the proposed set is an air dryer as sketched on plate 3. This consists of a cup containing some hygroscopic substance, for instance, potassium hydrate. The

cup can be threaded to the lid containing the air-holes; and it can be removed and set upon a stove to dry the crystals from time to time. This air dryer, it is believed will increase the ozone production as well as avoid the production of dangerous nitrogen compounds said to be due to the presence of moisture in the air passing through the corona.

The power measurements showed the one air space for the best distance to consume 18 watts. Ten spaces therefore would require a consumption of 10 x 18 = 180 watts which is about three times the power taken by a 16 candle power incandescent lamp. The power consumption of the proposed ozonizer is therefore a small item. This is true even considering a low efficiency of the transformer used to raise the voltage.

It is believed that the small ozone water sterilizer could be developed into a successful and valuable addition to the home.

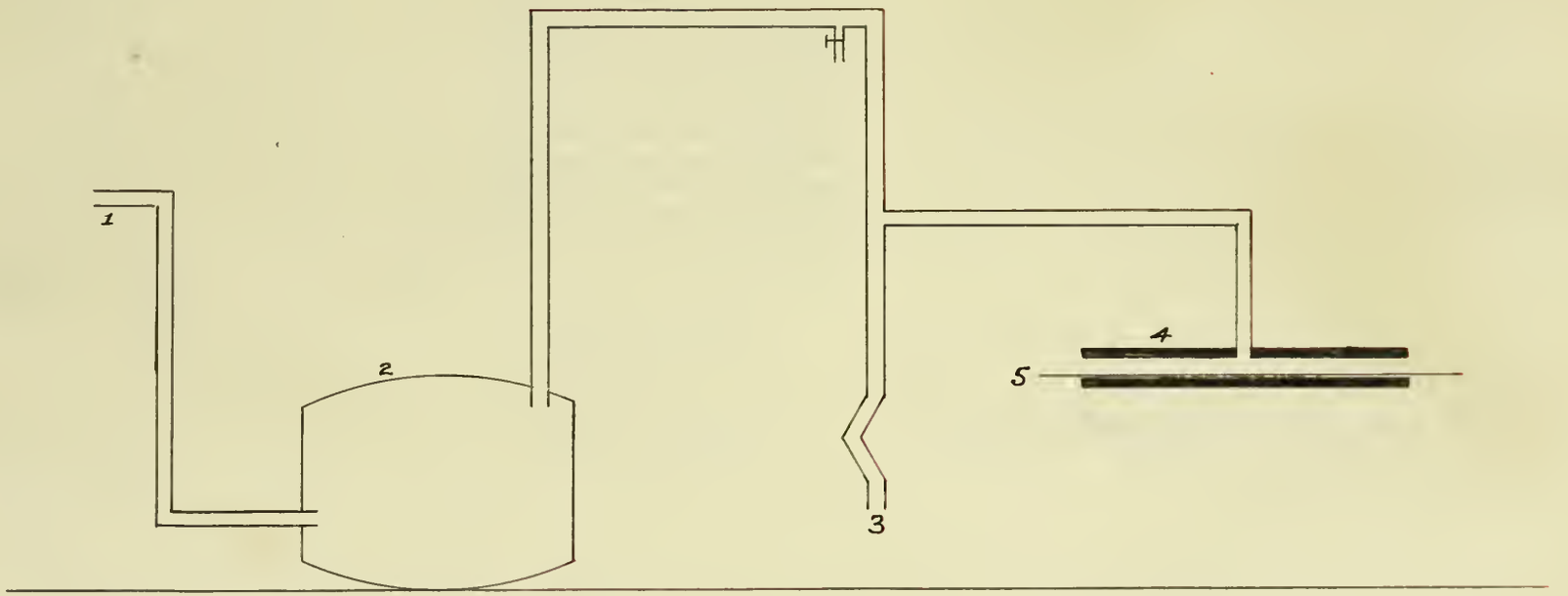
# PLATE 1. DIAGRAMATIC SKETCH OF APPARATUS USED FOR MEASUREMENT OF OZONE CONCENTRATION




EXPLANATION :

1. ASPIRATOR
2. GAS METER
3. WASH BOTTLES
4. CONDENSER
5. MICA DIELECTRIC
6. TRANSFORMER
7. VOLTMETER
8. RHEOSTAT

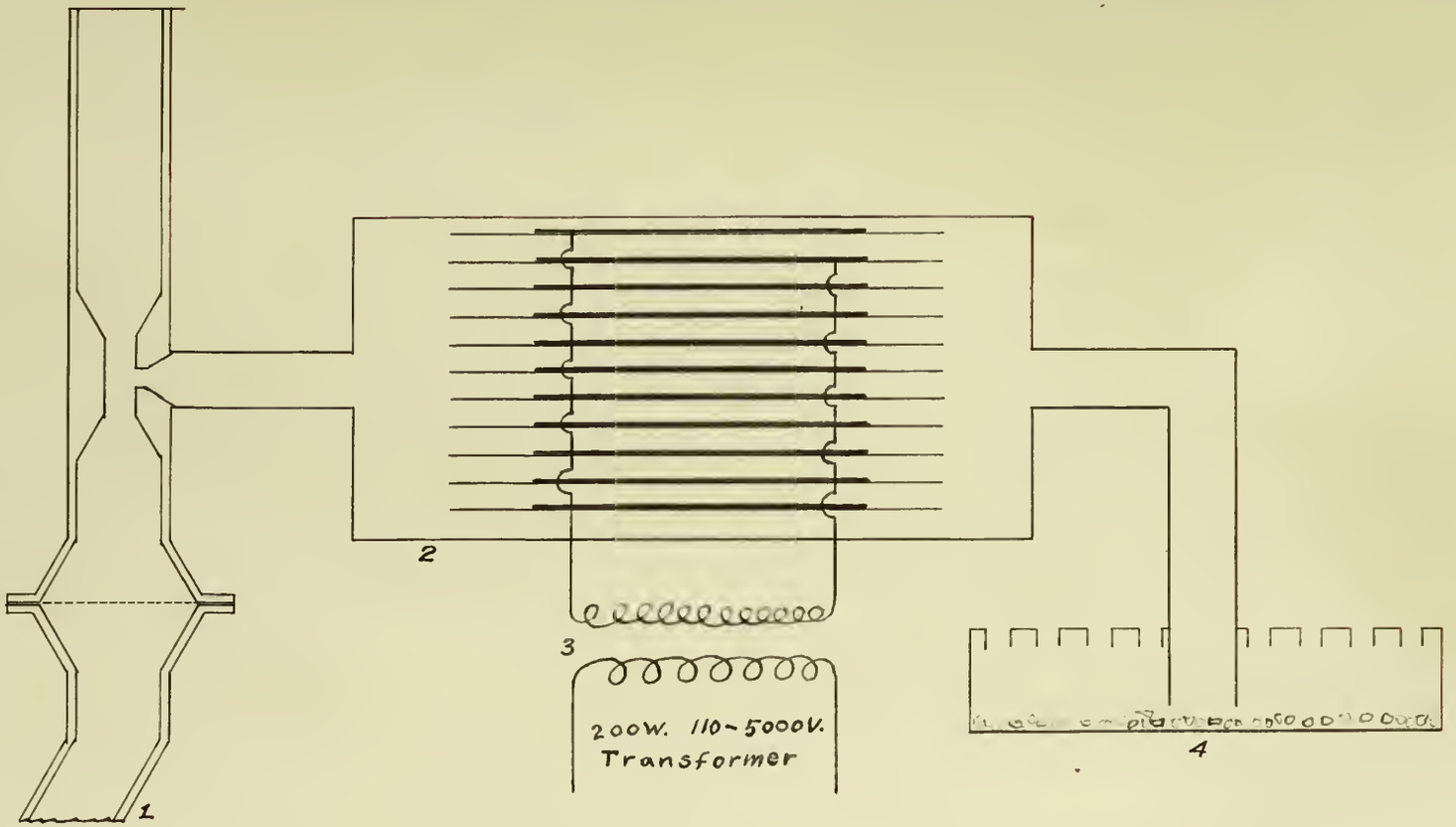
PLATE 2. DIAGRAMATIC SKETCH OF APPARATUS USED FOR WATER PURIFICATION TESTS




EXPLANATION:

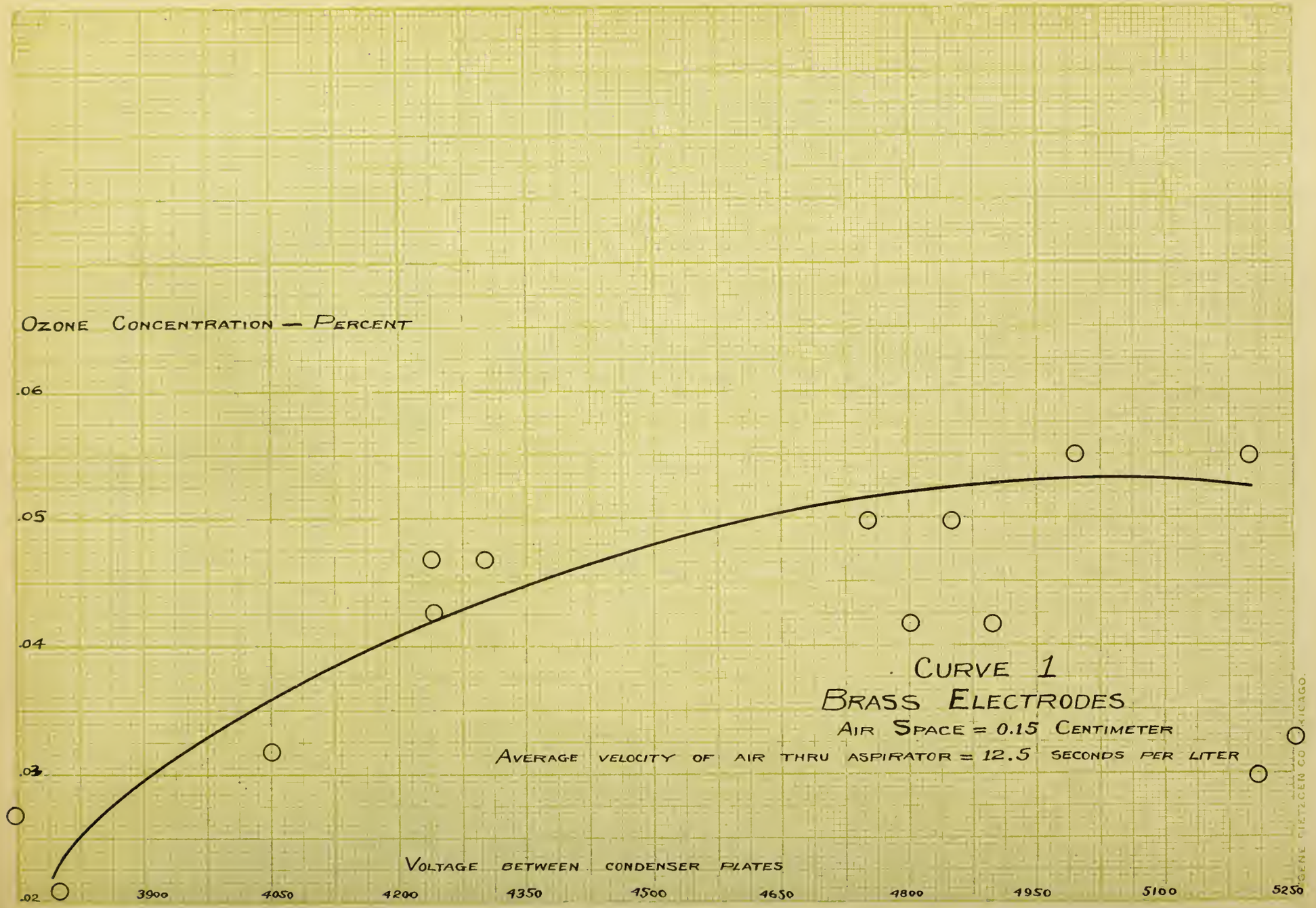
1. WATER MAIN
2. IMPURE WATER VESSEL
3. ASPIRATOR
4. CONDENSER
5. MICA DIELECTRIC

# PLATE 3. DIAGRAMATIC SKETCH OF PROPOSED OZONIZER




EXPLANATION :

1. ASPIRATOR
2. CONDENSER
3. TRANSFORMER
4. VESSEL CONTAINING HYGROSCOPIC CRYSTALS


Ozone Concentration — Percent
.06
.05
.04
.03
.02
3900
4050
4200
4350
4500
4650
4800
4950
5100
5250
Voltage between condenser plates
Curve 1
Brass Electrodes
Air Space = 0.15 Centimeter
Average velocity of air thru aspirator = 12.5 seconds per liter
EUGENE DIETZGEN CO. CHICAGO.

Voltage -- Ozone Curve #1.

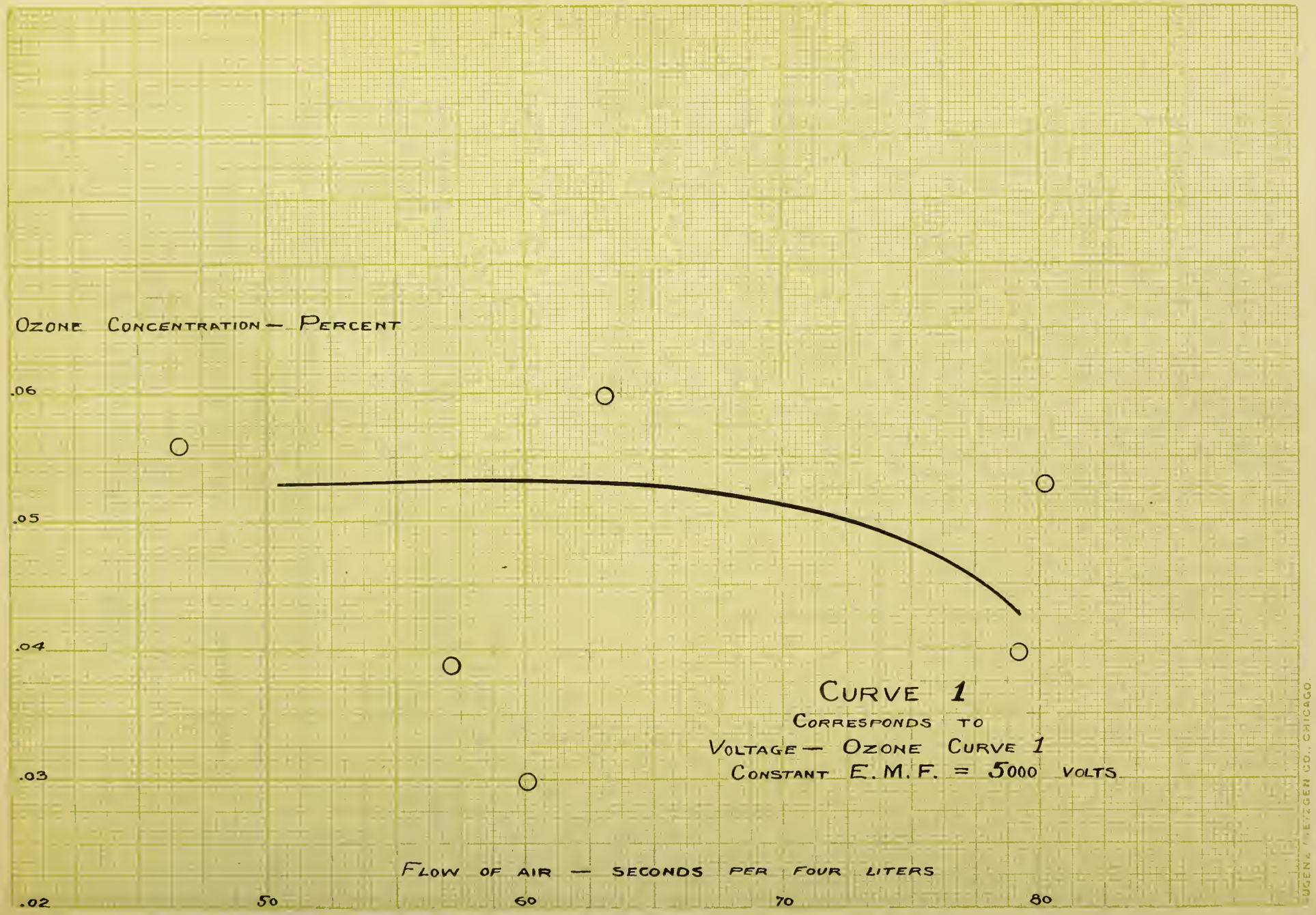
2 Brass Plates (upper plate = 4" square)

Air Space (does not include dielectric) = 0.15 centimeter.

Dielectric (mica) = .023 centimeters thick.

4 litres of air drawn thru condenser for each test.

| Voltage between Condenser Plates | Time Seconds | Sodium Thiosulphate cubic centimeters | Ozone Percent in 1 litre of air. |
|---|---|---|---|
| 3750 | 50 | 9.5 | .027 |
| 3850 | 60 | 7.35 | .021 |
| 4950 | 65 | 11.2 | .032 |
| 4250 | 46 | 16.95 | .047 |
| 4250 | 54 | 15.35 | .043 |
| 4300 | 53 | 16.65 | .047 |
| 4350 | 50 | 9.55 | .027 |
| 4750 | 49 | 17.75 | .05 |
| 4800 | 48 | 15.05 | .042 |
| 5000 | 49 | 19.65 | .055 |
| 5200 | 47.5 | 12.7 | .030 |
| 5250 | 49 | 11.65 | .033 |


Ozone Concentration — Percent
.06
.05
.04
.03
.02
50
60
70
80
Flow of air — seconds per four liters
Curve 1
Corresponds to
Voltage — Ozone Curve 1
Constant E.M.F. = 5000 volts

Speed -- Ozone Curve # 1.

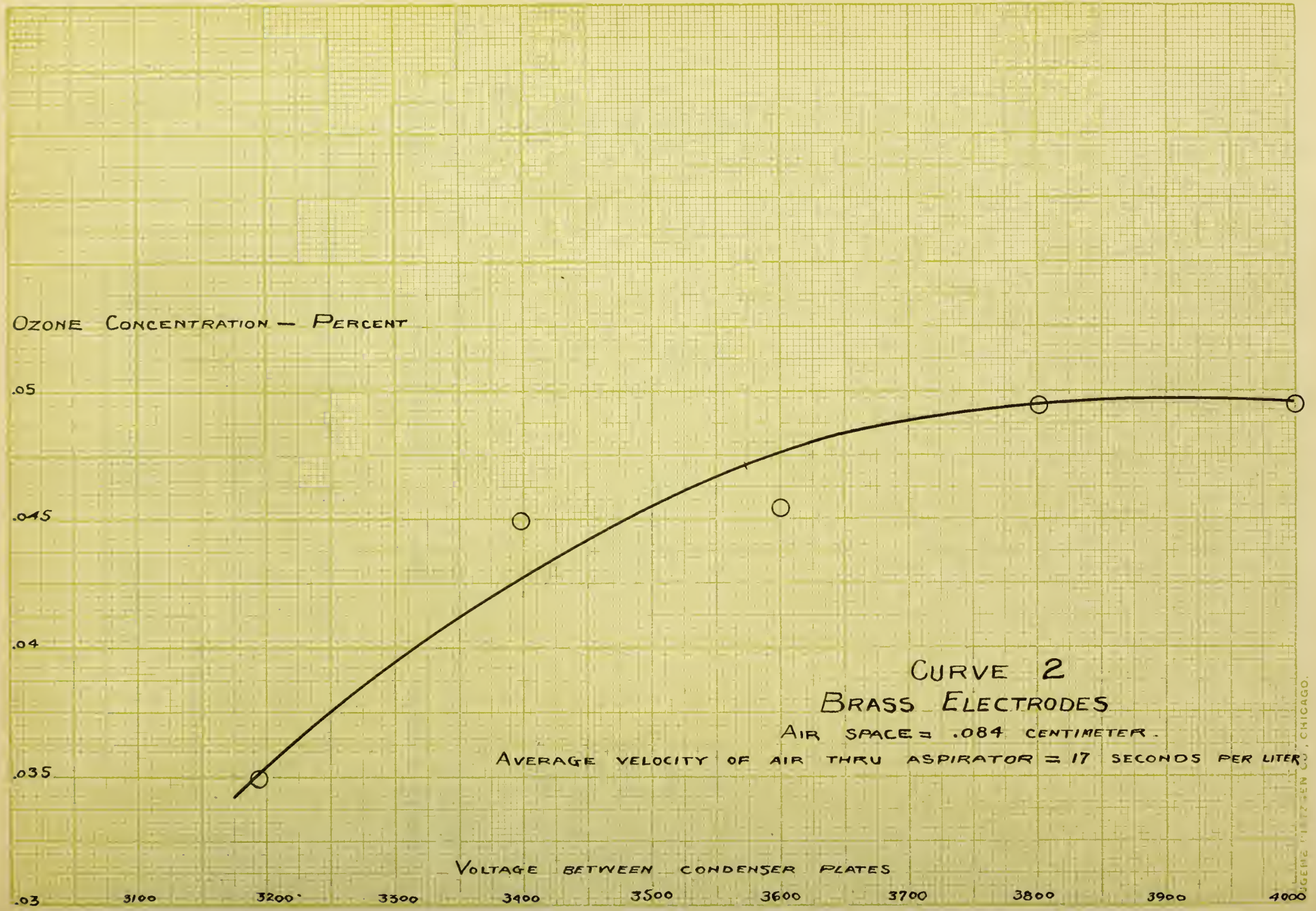
(corresponds to "Voltage - Ozone Curve #1")

"Speed" means rate of flow of air thru condenser.

Voltage between condenser plates = 5000

4 litres of air were drawn thru condenser for each test.

| Time seconds per 4 litres of air | Sodium Thiosulphate cubic centimeters | Ozone per cent in 1 litre of air |
|---|---|---|
| 46.5 | 18.05 | .056 |
| 57.0 | 13.85 | .039 |
| 60 | 10.85 | .030 |
| 63 | 21.45 | .060 |
| 79 | 14.2 | .040 |
| 80 | 18.75 | .053 |
| 1804 | 8 | .022 |




CURVE 2

BRASS ELECTRODES

AIR SPACE = .084 CENTIMETER.

AVERAGE VELOCITY OF AIR THRU ASPIRATOR = 17 SECONDS PER LITER.

EUGENE DIETZGEN CO., CHICAGO.

Voltage -- Ozone  Curve # 2.

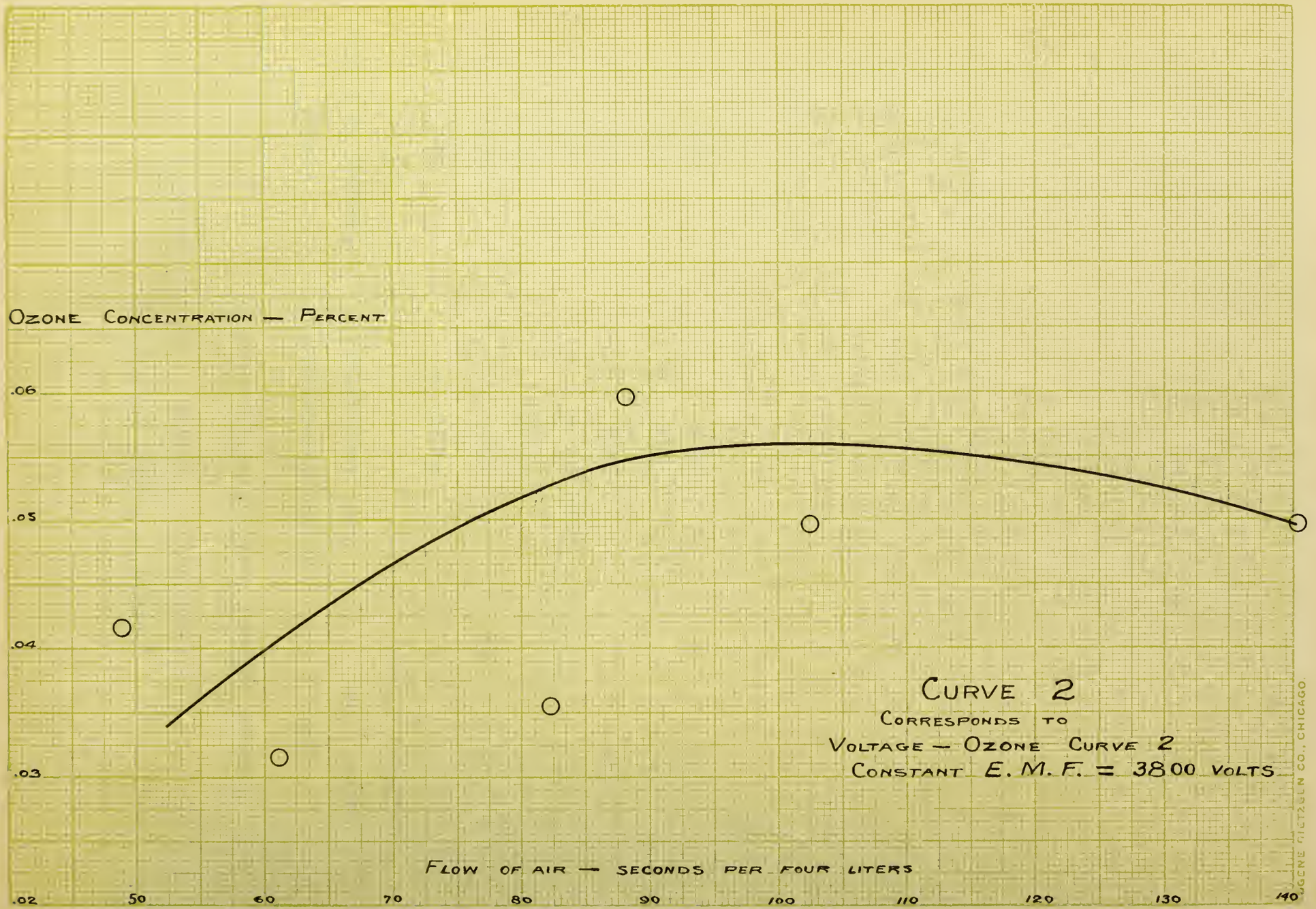
Brass Plates

Air Space = .084 Centimeters

Dielectric = .023 centimeter

4 litres of air drawn thru condenser for each test.

| Voltage between condenser plates | Time seconds | Thiosulphate cubic centimeters | Ozone Percent in 1 litre of air |
|---|---|---|---|
| 4000 | 64 | 17.6 | .049 |
| 3800 | 66 | 17.55 | .049 |
| 3600 | 70 | 16.5 | .046 |
| 3400 | 70 | 16.05 | .045 |
| 3200 | 66 | 12.65 | .035 |

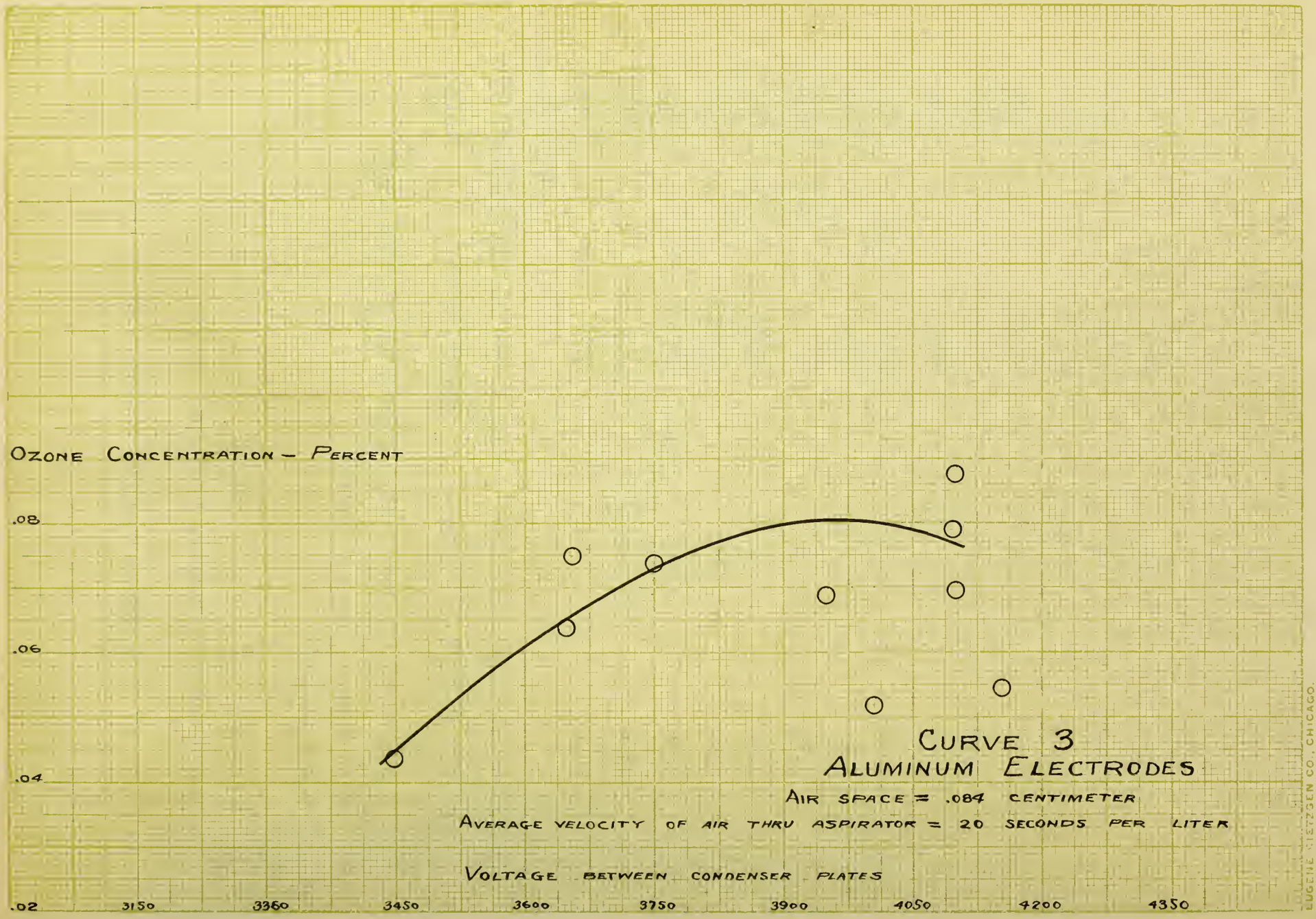

Ozone Concentration — Percent
.06
.05
.04
.03
.02
Flow of air — seconds per four liters
50
60
70
80
90
100
110
120
130
140
Curve 2
Corresponds to
Voltage — Ozone Curve 2
Constant E. M. F. = 3800 volts
EUGENE DIETZGEN CO., CHICAGO

Speed -- Ozone Curve # 2.

(corresponds to "Voltage - Ozone Curve #2")

Voltage between condenser plates = 3800

| Time seconds per 4 litres of air | Sodium Thiosulphate cubic centimeters | Ozone percent in 1 litre of air |
|---|---|---|
| 49 | 14.85 ? | .042 |
| 44 | 10.4 | .029 |
| 88 | 21.45 | .060 |
| 140 | 17.75 | .050 |
| 102 | 17.9 | .050 |
| 61 | 11.5 ? | .032 |
| 82 | 12.7 | .036 |




CURVE 3
ALUMINUM ELECTRODES
AIR SPACE = .084 CENTIMETER
AVERAGE VELOCITY OF AIR THRU ASPIRATOR = 20 SECONDS PER LITER

EUGENE DIETZGEN CO., CHICAGO.

Voltage -- Ozone Curve # 3.

Top plate of condenser aluminum, 4" x 4"

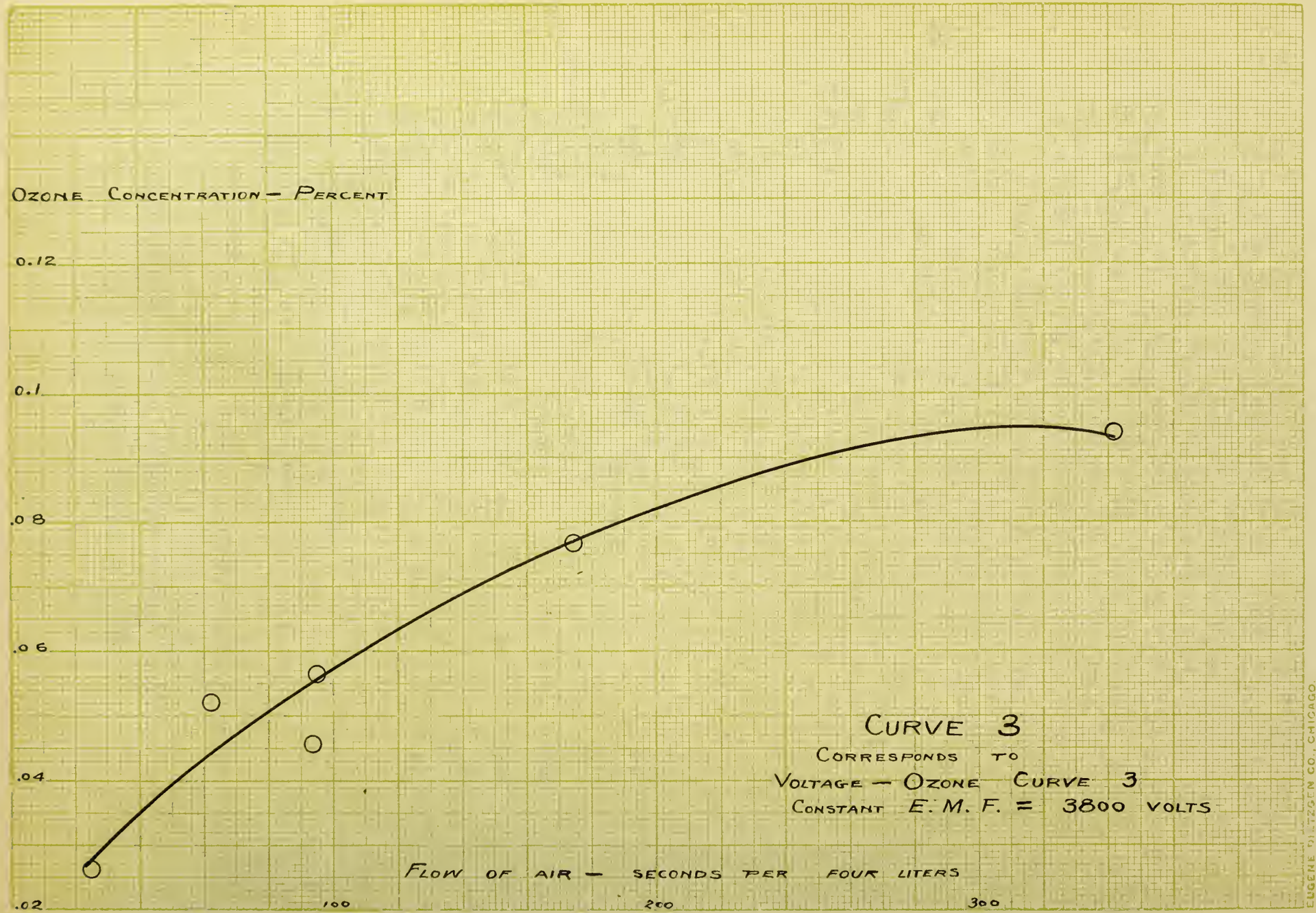
Bottom " " " brass.

Dielectric #4

Air space = .084 centimeter.

4 litres of air drawn thru condenser for each test.

| Voltage between condenser plates | Time seconds | Thiosulphate cubic centimeters | Ozone percent in 1 litre of air. |
|---|---|---|---|
| 3050 | 75 | 7.5 | .021 |
| 3450 | 80 | 15.8 | .044 |
| 3650 | 138 | 22.9 | .064 |
| 4000 | 83 | 18.65 | .052 |
| 4150 | 79 | 19.5 | .055 |
| 4150 | 90 | 15.7 | .044 |
| 3850 | 78.5 | 15.8 | .044 |
| 3750 | 78 | 26.4 | .074 |
| 3650 | 77 | 26.55 | .075 |
| 3950 | 76 | 24.75 | .069 |
| 4200 | 76.5 | 28.65 | .080 |
| 4100 | 76.25 | 26.05 | .070 |
| 4100 | 77. | 24.00 | .067 |
| 4100 | 77. | 31.3 | .088 |

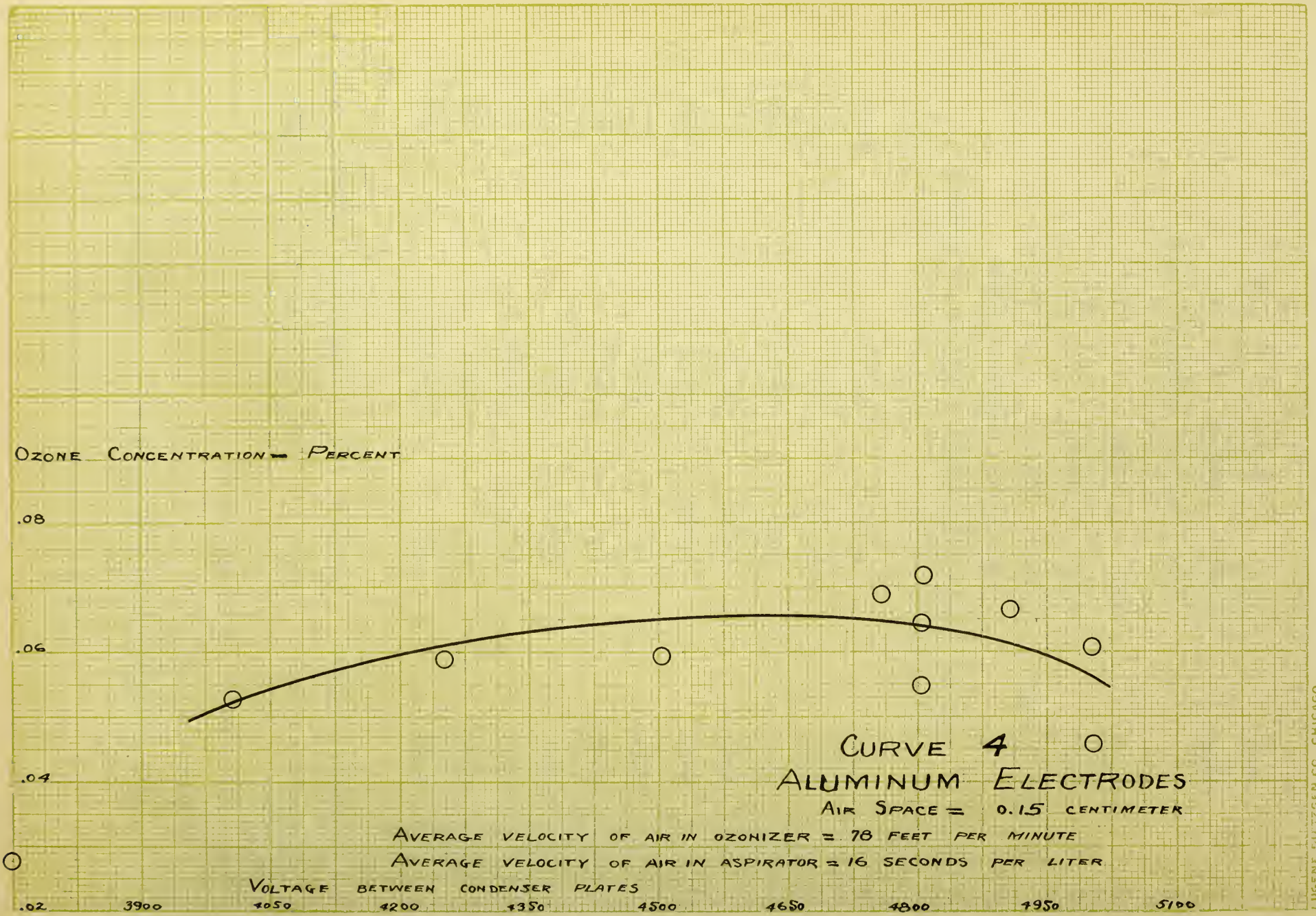

Ozone Concentration — Percent
0.12
0.1
.08
.06
.04
.02
100
200
300
Flow of air — seconds per four liters
Curve 3
Corresponds to
Voltage — Ozone Curve 3
Constant E. M. F. = 3800 volts
EUGENE DIETZGEN CO., CHICAGO

Speed -- Ozone Curve # 3

(corresponds to "Voltage - Ozone Curve #3")

Voltage between condenser plates = 3800

| Time Seconds | Thiosulphate cubic centimeters | Ozone Percent in 1 litre of air |
|---|---|---|
| 26 | 10.1 | .028 |
| 760 | 43.05 | .120 |
| 174 | 27.7 | .078 |
| 341.6 | 33.9 | .095 |
| 94 | 16.8 | .047 |
| 62 | 19.35 | .054 |
| 95 | 20.65 | .058 |




Curve 4

Aluminum Electrodes

Air Space = 0.15 centimeter

Average velocity of air in ozonizer = 78 feet per minute

Average velocity of air in aspirator = 16 seconds per liter

EUGENE DIETZGEN CO., CHICAGO

Voltage -- Ozone Curve # 4.

Same condenser plates as in # 3 4 litres in 53 sec.

Dielectric # 5

Air Space = 0.15 centimeter

| Voltage between condenser plates | Time seconds | Thiosulphate cubic centimeters | Ozone percent in 1 litre of air. |
|---|---|---|---|
| 5000 | 50 | 16.25 | .046 |
| 4750 | 50 | 24.5 | .069 |
| 4500 | 51.75 | 21.35 | .060 |
| 4250 | 55.00 | 20.85 | .059 |
| 4000 | 54. | 19.00 | .053 |
| 3750 | 50 | 10.01 | .028 |
| 4850 | 55.25 | 25.85 | .072 |
| 5000 | 54.00 | 21.9 | .061 |
| 4800 | 56.5 | 19.65 | .055 |
| 4900 | 55.0 | 24.1 | .067 |
| 4800 | 52.0 | 23.45 | .065 |

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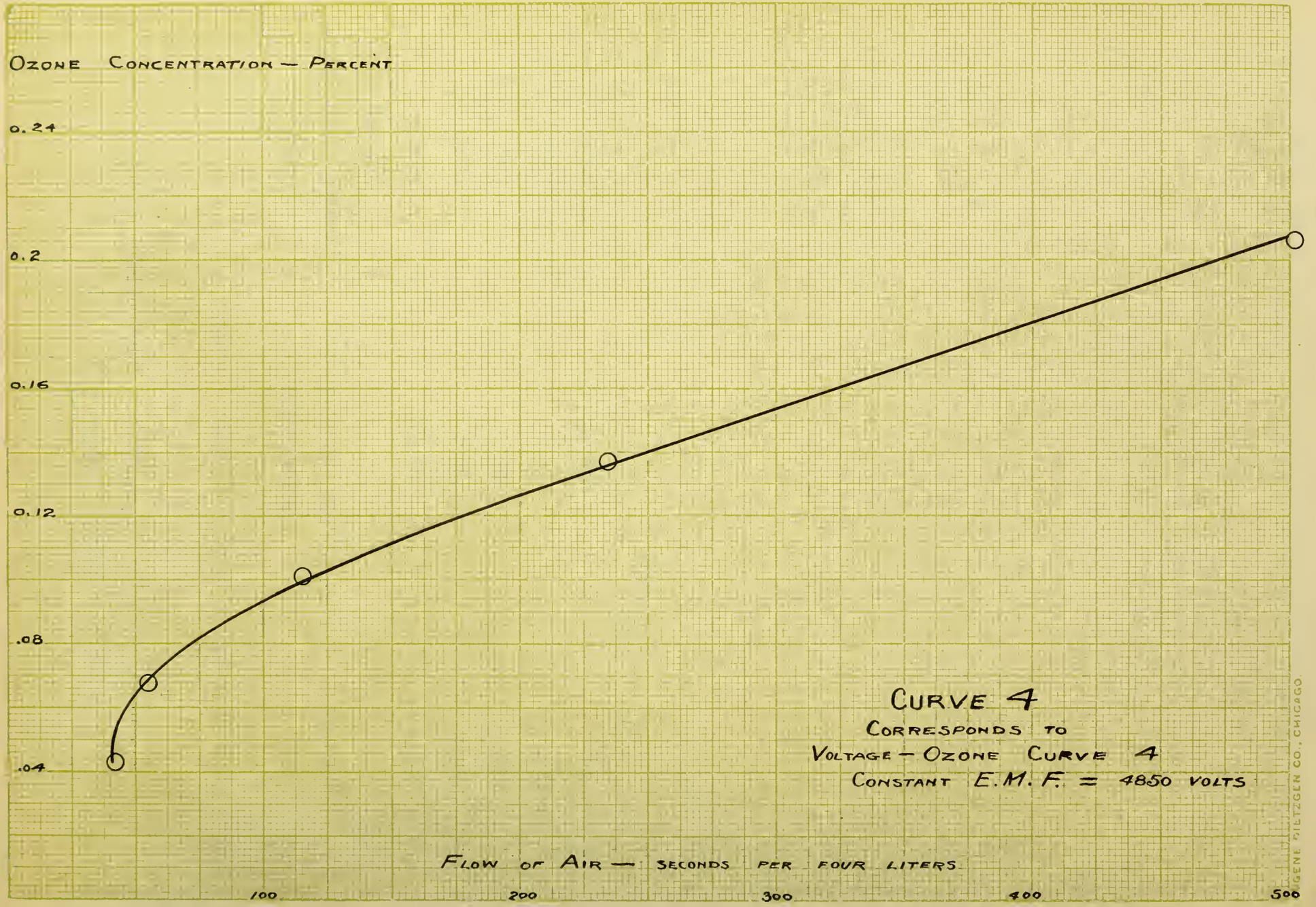
Current Density and Power consumed in Corona.

For .15 cm. Between Plates

| E M F Volts | I amp. | I/D" | W watts |
|---|---|---|---|
| 4800 | .00375 | .00029 | 18. |
| 5000 | .0049 | .00038 | 23.5 |

For .084 cm. Between Plates

| | | | |
|---|---|---|---|
| 4800 | .00542 | .00042 | 26. |
| 5000 | .0057 | .00044 | 28.5 |


Ozone Concentration — Percent
0.24
0.2
0.16
0.12
.08
.04
Flow of Air — Seconds per four liters
100
200
300
400
500
Curve 4
Corresponds to
Voltage — Ozone Curve 4
Constant E.M.F. = 4850 volts
EUGENE DIETZGEN CO., CHICAGO

Speed -- Ozone Curve # 4.

(corresponds to "Voltage - Ozone Curve # 4")

Voltage between condenser plates = 4850

| Time seconds | Thiosulphate cubic centimeters | Ozone percent in 1 litre of air |
|---|---|---|
| 40.7 | 16.65 | .047 |
| 526.5 | 76.2 | .213 |
| 229 | 48.1 | .135 |
| 118 | 37.8 | .106 |
| 54 | 25.85 | .072 |

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